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## AN ANALYTICAL STUDY OF ATHLETIC RECORDS

By GEORGE P. MEADE

CARDENAS, CUBA

IN June, 1915, Norman Taber, formerly of Brown University Oxford, ran a mile in 4 minutes  $23\frac{1}{2}$  seconds, about two seconds faster than any amateur had ever been credited with running that distance. The question may have occurred to some of us at that time "How far can the breaking of records continue?" Improvement in technique or in method may affect such records as the high jump and pole vault; changes in apparatus may affect others such as the hammer throw, but running is an act so natural and free from "knack" that it would seem probable that there is some rule governing the rate at which a man can run—some limit which the records approach and beyond which they are not likely to go. Before looking into the matter further let us consider the class of figures with which we have to deal.

Athletic records have every right to consideration as scientific data. Races are timed by at least three skilled timers; distances are accurately surveyed and are remeasured in case a claim for a record is to be made. Strict rules are observed to prevent mistake or fraud at the start and finish, and unusual circumstances, such as favoring winds, are noted by judges or referee. Finally the performance is investigated by a committee of the national athletic board of the country in which the record was run, and every circumstance which might affect the validity of the record is discussed before the record is sanctioned. (These precautions apply only to amateur athletics. Professional races are run under less favorable conditions, and timing is unreliable, so professional records are not to be dealt with here at all.)

Athletic events may be divided into two classes—those which are run in all championship meets, and for which athletes practise regularly, and those which are run more rarely and for which practise is incidental. Of the first class, which we might term "standard" events, are the 100-yd., 220-yd. and 440-yd. dashes, the half-mile, mile, two-mile and five-mile runs. It is in these standard events that world-wide competition has been going on for many years. So many thousands of runners have striven to break these records that they may be taken as close approximations of the best which *man* can do, rather than as representing the best which men have been able to do so far.

In order to compare the speeds at various distances it is necessary to compute the rate for some unit distance. For distances below five miles the seconds per 100 yds. is used as the unit. (For example, the record for the half mile is 1 min. 52½ secs., or 112.5 secs. The rate per 100 yds. is  $\frac{112.5}{8.8}$  or 12.79 seconds.) For distances greater than five miles the rate is computed to seconds per mile.

Let us consider the world's best running records for the standard distances as given in Spalding's Athletic Almanac for 1915. The last column gives the rate per hundred yards, computed as shown above.

Distance	Time	Holder	Rate per 100 Yds.
100 yds.....	9½ secs.	Kelly	9.60 secs.
220 yds.....	21½ "	Wefers	9.59 "
440 yds.....	47½ "	Long	10.86 "
880 yds.....	1:52½ "	Meredith	12.79 "
One mile.....	4:12½ "	Taber	14.35 "
Two miles.....	9:09½ "	Shrubb	15.60 "
Three miles.....	14:17½ "	Shrubb	16.22 "
Four miles.....	19:23½ "	Shrubb	16.52 "
Five miles.....	24:33½ "	Shrubb	16.73 "

A study of these rates shows that for the 100-yd. dash and the 220-yd. dash the rate is practically identical. Here the fatigue in running the longer distance is offset by the greater effect of the delay at the start on the rate of the shorter dash. Beginning with the 220-yd. dash rate,

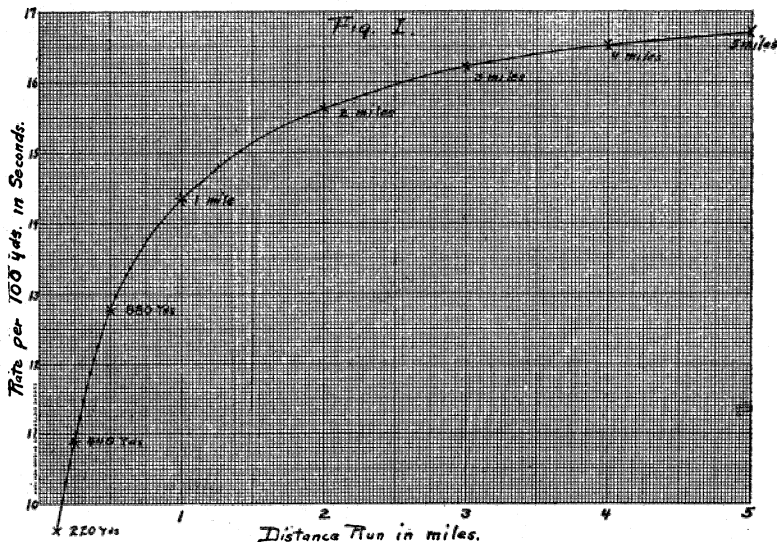


FIG. 1. CURVE REPRESENTING THE RELATIONSHIP, FOR THE STANDARD DISTANCES, BETWEEN THE RATE OF SPEED AND THE DISTANCE COVERED.

however, we note that the rates increase for each succeeding distance, but with a constantly decreasing increment.

Representing the rates as vertical distances and the miles as horizontal distances, we can show graphically the relationship between the rates, as in Fig. 1.

The smoothness of the curve connecting all the points plotted is striking—so striking, indeed, as to indicate strongly that there is an approach to a definite relationship between the various records which have been reduced by extended competition. No claim is made that the limit has been reached in the breaking of these records. Such a claim might be refuted by actual performance in the next athletic meet. But the probability of any marked change in the records represented by the curve is very remote.

To show the effect of competition on the rates, let us plot some of the second class of events (that is, those which are run more rarely). As instances we will choose the following:

Distance	Time	Holder	Rate per 100 Yds.
1,000 yards.....	2:12 $\frac{2}{5}$	Sheppard	13.40
$\frac{3}{4}$ mile.....	3:02 $\frac{1}{4}$	Conneff	13.84
1 $\frac{1}{2}$ miles.....	6:46 $\frac{2}{5}$	Conneff	15.39

These points are plotted in Fig. 2, together with the curve already shown in Fig. 1. The points, as might have been expected, fall outside the curve.

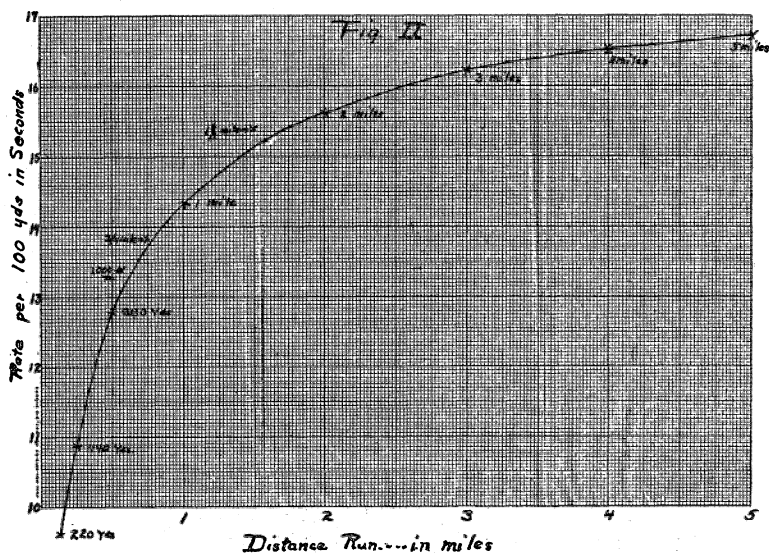


FIG. 2. THE SAME CURVE AS IN FIG. 1, TOGETHER WITH POINTS PLOTTED FOR RATE AND DISTANCE FOR 1,000 YDS.,  $\frac{3}{4}$  MILE AND 1 $\frac{1}{2}$  MILES. Showing that for distances in which competition has been less keen the points fall outside the curve.

the curve. The rate for these less usual events is, therefore, greater than in the standard events. There is little doubt that if these distances were included in the regular schedule of championship events the records would fall until the points were included in our curve.

For convenience in studying the records for distances beyond five miles the rates are calculated to seconds per mile, instead of seconds per 100 yards. Following are the records and calculated rates:

Distance	Time	Holder	Rate per mile
440 yds.....	47 $\frac{1}{2}$ secs.	Long	191.2 secs.
$\frac{1}{2}$ mile.....	1:52 $\frac{1}{2}$ "	Meredith	225.0 "
One mile.....	4:12 $\frac{3}{4}$ "	Taber	252.6 "
Two miles.....	9:09 $\frac{3}{4}$ "	Shrubb	274.8 "
Three miles.....	14:17 $\frac{1}{2}$ "	Shrubb	285.8 "
Four miles.....	19:23 $\frac{3}{4}$ "	Shrubb	290.8 "
Five miles.....	24:33 $\frac{1}{2}$ "	Shrubb	294.7 "
Ten miles ...	50:40 $\frac{3}{5}$ "	Shrubb	304.0 "
11.82 miles.....	One Hour	Bouin	304.4 "
Fifteen miles.....	1:20:04 $\frac{3}{5}$ "	Appleby	320.3 "
Twenty miles.....	1:51:54 "	Grossland	335.7 "
Twenty-five miles.....	2:29:29 $\frac{3}{5}$ "	Green	358.7 "

These rates and distances are shown in Fig. 3. The one-hour record seems to be a continuation of the smooth curve obtained for the shorter

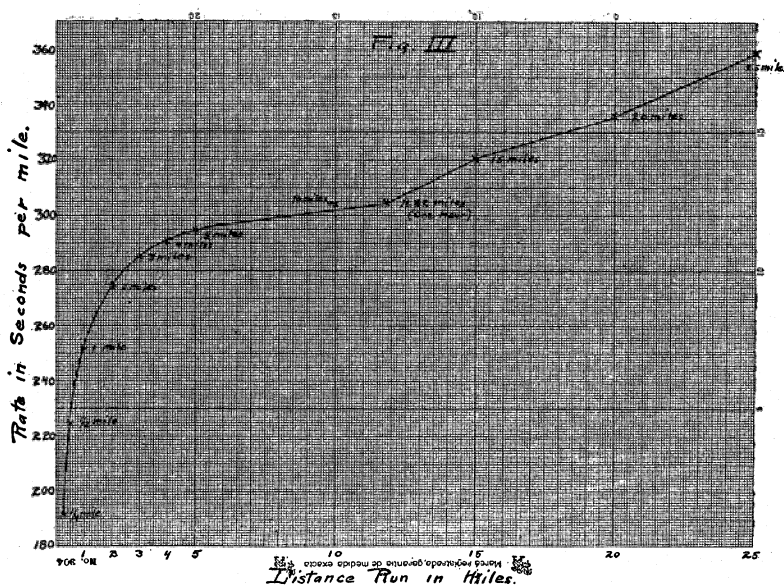


FIG. 3. THE RELATIONSHIP BETWEEN RATE OF SPEED AND DISTANCE RUN CONTINUED FOR RECORDS UP TO 25 MILES. (The rate here is in seconds per mile, instead of seconds per 100 yds., as in Figs. 1 and 2.)

distances, with the ten-mile record slightly out of line. It is of interest to note that this ten-mile record was made by Shrubb while he was

making the one-hour record formerly held by him. It is evident that if either Shrubb or Bouin had been running only ten miles, instead of for one hour on the day their records were made, the ten-mile record would be better and the point would fall within the curve.

Beyond the one-hour mark the curve breaks badly. Correct figures on professional races for the greater distances might tell a different story. In these longer races a money incentive might do more toward bringing out the full extent of man's abilities. Or it may be that whatever rule governs the records in the shorter distances does not apply in the longer ones. This does not seem as probable, however, as that the full possibilities have not been realized.

We have seen, then, that for those distances up to ten miles in which competition has been most intense there is apparently a rule governing the relationship between the distance covered and the rate. It may be that some mathematician who still has an interest in the sporting page will develop the formula on which this relationship is based.